Developing Agents Populations through Ethogenetics

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Some issues related to MAS adaptivity and organization

Problems:

- Explicit prior design for real-world problems
- Coping with necessary reorganizations

We consider organization :

- as an emergent property of the system
- as a permanent process

Organism

- Adaptation of the whole system to its environment
- Emergence of a global behavior
- Possible perception of «self» (self-adaptation to perceptions, regulation...)

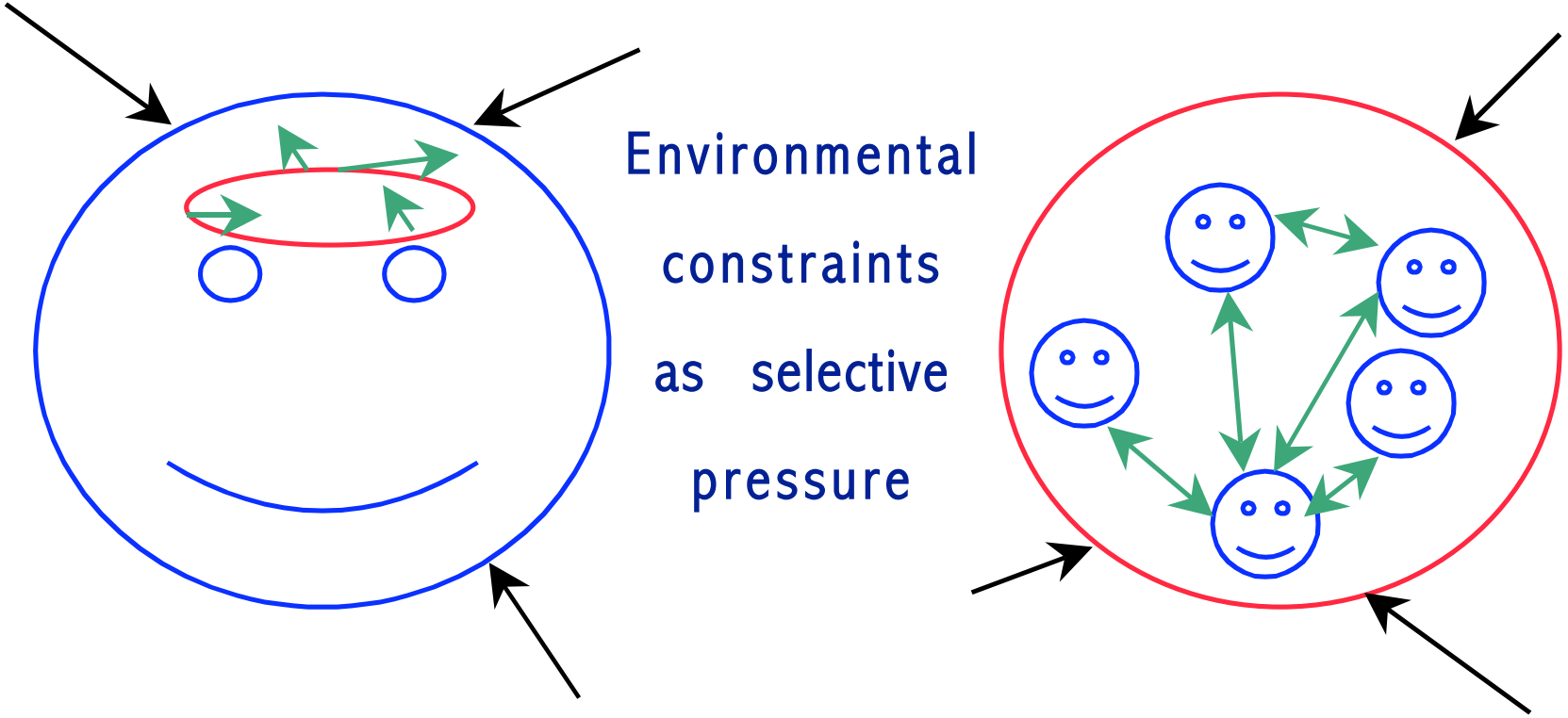
- Development of the system = ontogenetic process

Ecosystem

- Adaptation of each agent to its own environment
- Emergence of an organization in the system
- Collective learning process relying on the situatedness of the agents in the system

- Evolution of the agents in the system = phylogenetic process

Duality induced by the metaphors



Environmental constraints as selective pressure

Organism ⟺ **Ecosystem**

that develops (composed of agents)

Composed of agents that evolve

Purpose of our research

- Phylogenetic and ontogenetic processes = same phenomenon at different scales

- Proposal for self/system adaptation = the organization process of situated agents in the system

- Purpose = studying the evolutionary process that produces the organization, rather than the development process directly
  = how to have agents behaviors evolve in a situated system ? («□Ethogenetics»)

«Ethogenetics»

«Ethogenetics» is our approach to the design

of evolvable agent behaviors in a situated system

It implies the use of a structure for producing the behaviors of the agents, with the following requirements :

(1) It should allow for agents behaviors to be of any complexity

(2) It should allow cumulative adaptation in order to allow (3)

(3) It should be evolvable through a «blind» evolutionary process (e.g. Darwinian selection) which is a kind of unsupervised learning

(4) It should be understandable and manipulable directly by a human designer (for bootstraping, observation, modifications, explanation, reuse...)

Overview of evolutionary approaches

Genetic Algorithms, Evolutionary Strategies

(Holland, Schwefel)

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parameters

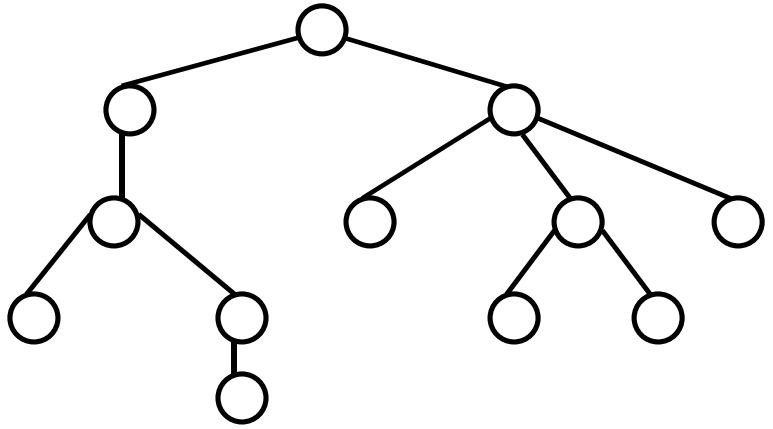
for a predefined behavior

+ continuity genotype ⇒ phenotype

- poor expressive power

Genetic Programming, Evolutionary Programm

(Koza, Fogel)



Executable structure

+ automatic behavior design

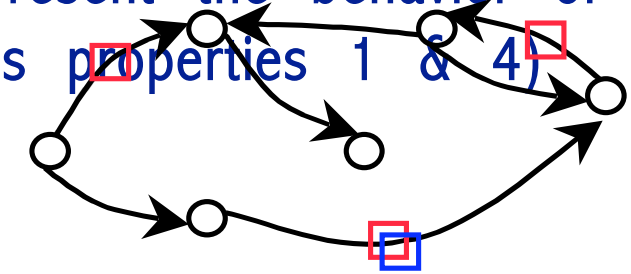
- strong and hierarchical dependencies between parts of the structure

The ATNoSFERES Model

Existing evolutionary approaches (e.g. Genetic Algorithms, Genetic Programming...) do not meet the 4 requirements simultaneously !

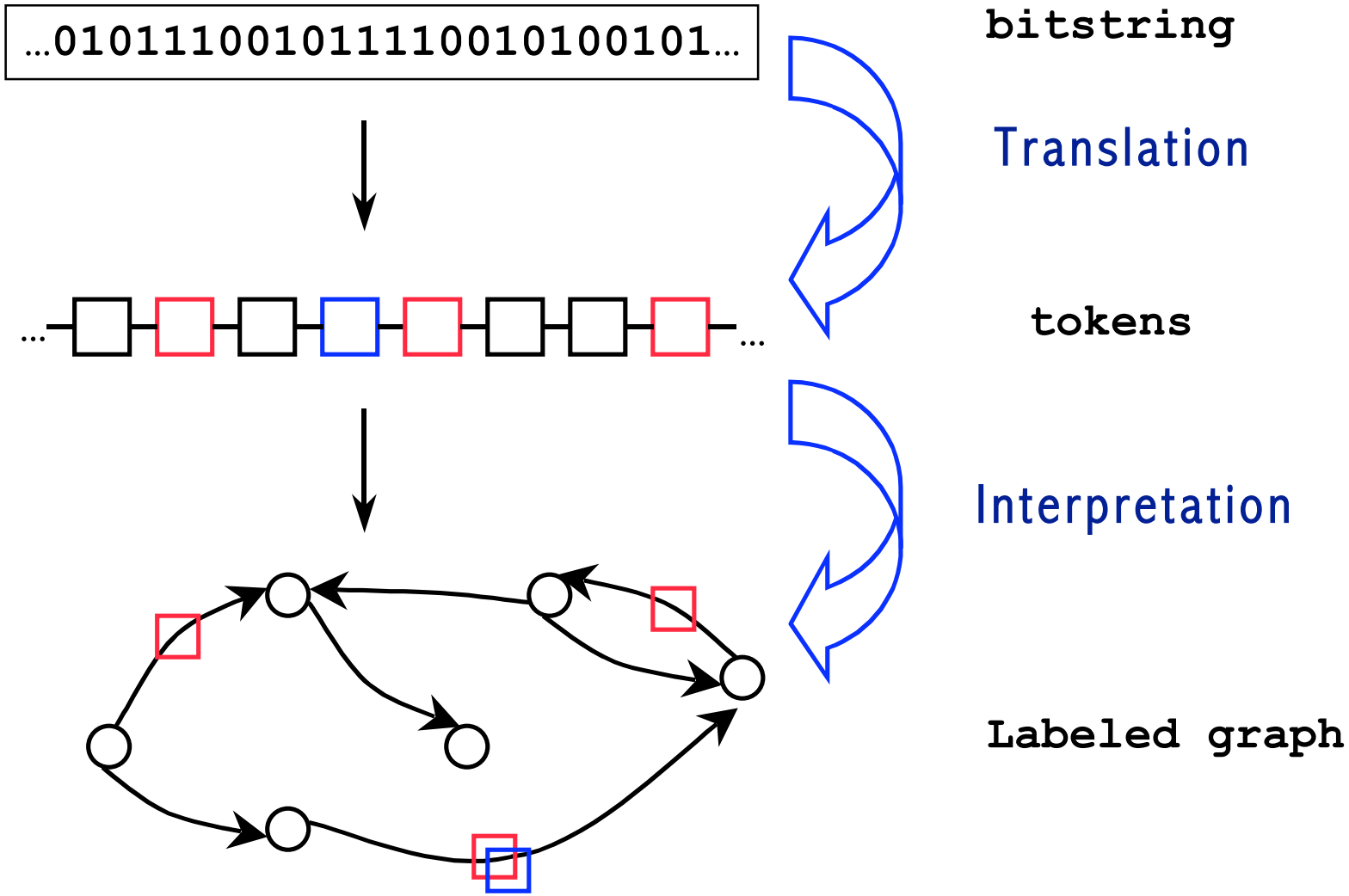
The model we propose as an illustration of Ethogenetics is based on:

- a non-deterministic automaton to represent the behavior of any agent (labeled ATN-like graph; ensures properties 1 & 4)

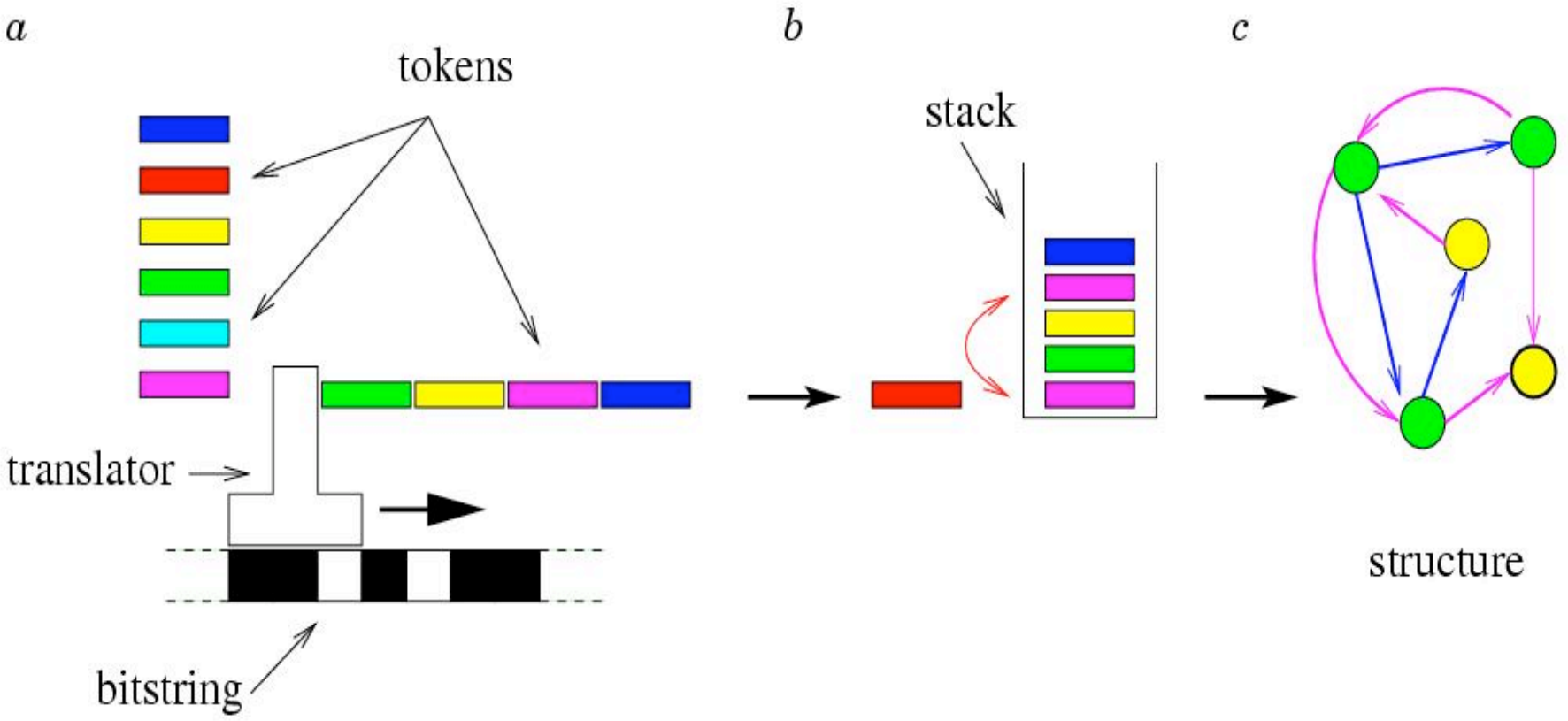


- a bitstring as hereditary substratum (gene) for building this automaton
- a stack-based gene expression process (to ensure properties 2 &

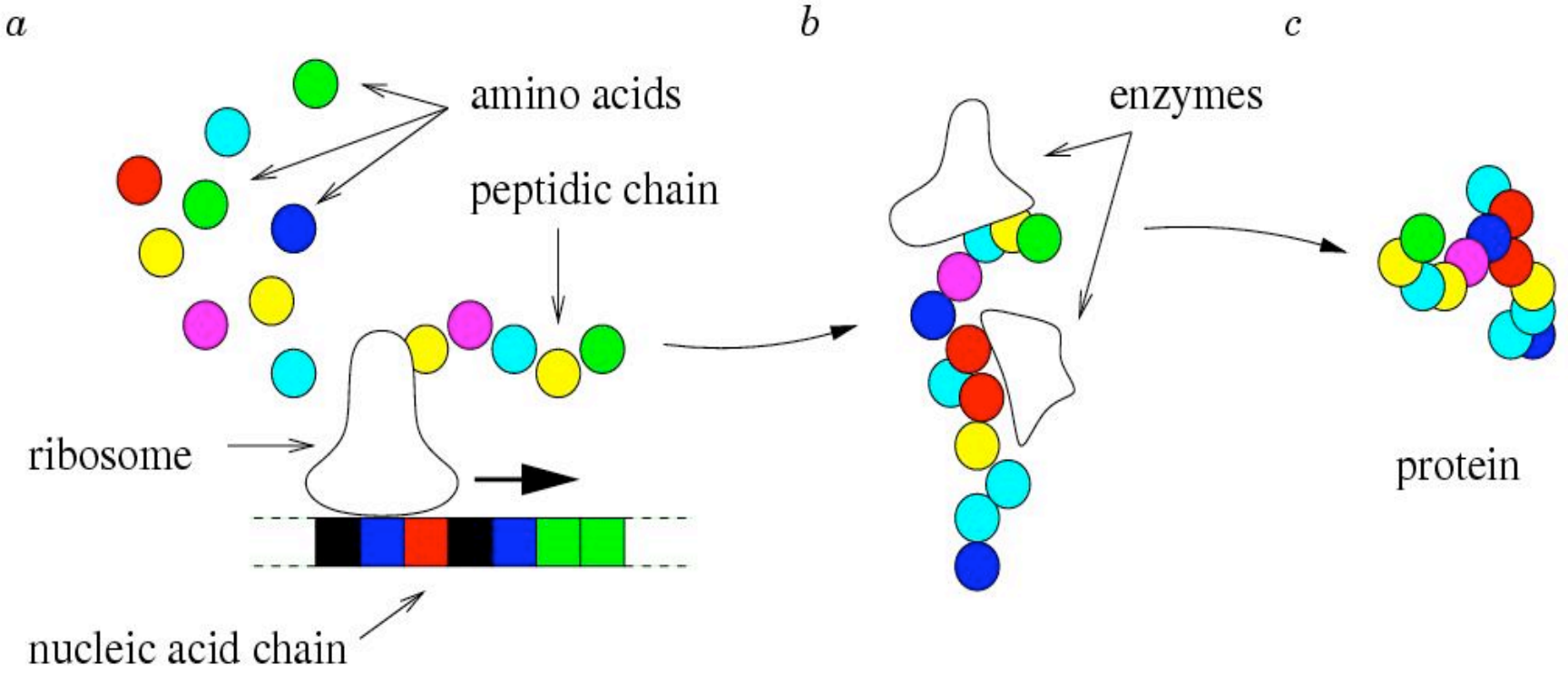
The *ATNoSFERES* model Agent architecture



Stack-based Gene Expression



Biological Gene Expression



Properties of the ATNoSFERES Model

- No specific hypothesis regarding the cognitive abilities of the agents
- Any genotype (bitstring) produces a consistent automaton
- Continuity between genotype (bitstring) and phenotype (ATN)
- Completeness of the ATN-building language

- Validation of the model through simple problems
- Exploitation on various maze problems
- Specific model properties

Conclusions & Perspectives

- Synthesis between evolutionary approaches and agent architectures
- Software engineering considerations (economy, reuse…)
- Adaptive behavior considerations (economy, inner states, structural representation…)

- Next experiments: predators/preys coevolution

- Applications to multi-robot experiments (MICRobES Project)
- Applications to network reliability/security (analogy with immune system)